SFB/TR32

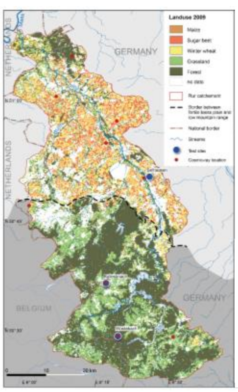
Analysis of Soil Moisture Patterns in a Mesoscale Catchment Using Plot to Catchment Scale Datasets

Wolfgang Korres, Karl Schneider
Tim G. Reichenau, Sabrina Esch

Hydrogeography and Climatology Research Group, Institute of Geography, University of Cologne
Subproject C3 in the SFB/TR32

General objectives

- Joined statistical analysis of surface soil moisture datasets
  - acquired across a variety of land use types
  - on different spatial scales (plot to mesoscale catchment)
  - with different methods (field measurements, remote sensing, and modelling)
- better understand temporal and spatial soil moisture patterns at different scales
- identify driving parameters and processes explaining these patterns and their temporal dynamics



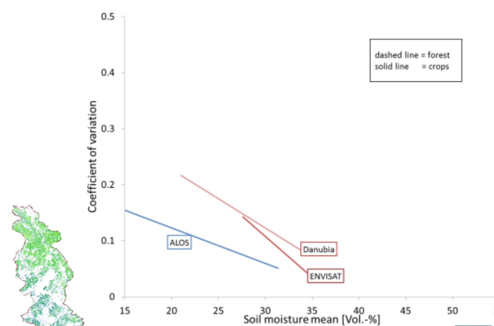
The Rur catchment

Soil moisture data sets:

Northern part (crops):
1) **ALOS**, L-Band radar remote sensing (15m)
2) **ENVISAT**, C-Band radar remote sensing (150m)
3) **Danubia**, model (150m)

Wüstebach sub-catchment (forest):
4) **SoilNet**, automated sensor network (5-50m)
5) **HydroGeoSphere**, model (5-50m)

Descriptive statistics: Spatial Mean – Coefficient of variation



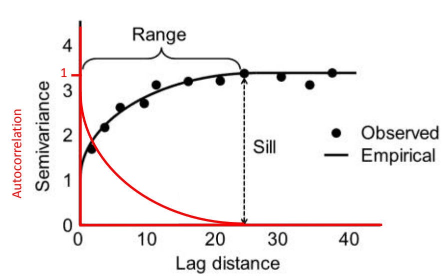
Autocorrelation

Tobler's first law of geography: "Everything is related to everything else, but near things are more related than distant things."

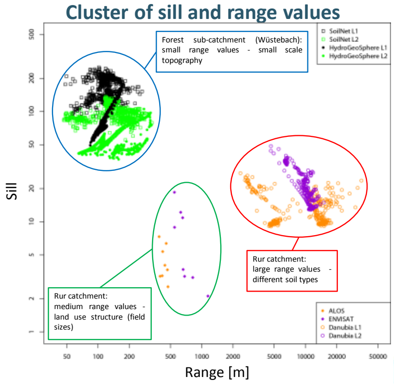
Tobler (1970): Economic Geography 46(2), 234-240

- Cross-correlation of a signal with itself
- Similarity between observations as a function of the space- or time-lag between them

Autocorrelation analysis with semivariograms

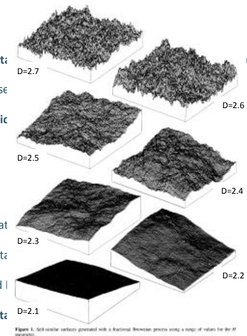


Cluster of sill and range values



Fracta… rot (1977)

- Description of se…
- **Fractal dimensic…**
- In geosciences:
  - various nat…
  - only consta…
  - separated l…
  - → **multi-fracta…**

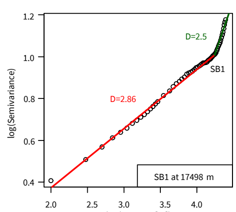


Goodchild and Mark (1987): Annals of the Association of American Geographers 77(2), 265-278

Mandelbrot (1977): Fractals: Form, Chance and Dimension

Fractals

Log-log plot of the semivariances:

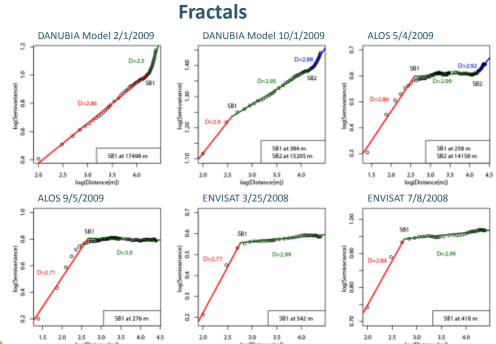


D = 3 – B / 2

with B as the slope of the regression line in the log-log plot of the variogram

Regression lines computed with the segmented regression method by Muggeo (2003): Estimating regression models with unknown break-points. Stat. Med. 22(19), 3055–3071

Fractals



Fertile loess plain

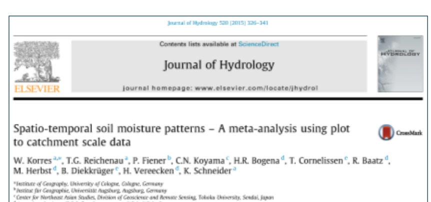
Conclusion

- **Three groups of datasets with consistent range parameters (geostatistics) and scale breaks (fractal analysis) were found**
  - associated with small scale topography (forest sub-catchment),
  - field sizes (Rur catchment) and
  - large scale variability of soil types (Rur catchment)
- Generally **high fractal dimensions**, high spatial variability of soil moisture
- **Multifractal behavior with at least one scale break**, indicating that various processes or driving parameters operate at different scales
- A multi-fractal model is seen as an **appropriate approach** to capture and describe the **nested scales of variability of soil moisture patterns**

Thank you for your attention

Acknowledgements:
We gratefully acknowledge financial support by the SFB/TR 32 "*Patterns in Soil-Vegetation-Atmosphere Systems: Monitoring, Modelling, and Data Assimilation*" funded by the German Science Foundation (DFG) and by TERENO "*Terrestrial Environmental Observatories*" funded by the Helmholtz Association and the Federal Ministry of Education and Research (BMBF).

Thanks to my co-authors:


Journal of Hydrology
Spatio-temporal soil moisture patterns – A meta-analysis using plot to catchment scale data
W. Korres, T.G. Reichenau, P. Fiener, C.N. Koyama, H.R. Bogena, T. Cornelissen, R. Baatz, M. Herbst, B. Diekkrüger, H. Vereecken, K. Schneider

Conclusion

- **Three groups of datasets with consistent range parameters (geostatistics) and scale breaks (fractal analysis) were found**
  - associated with small scale topography (forest sub-catchment)
  - field sizes (Rur catchment) and
  - large scale variability of soil types (Rur catchment)
- Generally **high fractal dimensions**, high spatial variability of soil moisture
- **Multifractal behavior with at least one scale break**, indicating that various processes or driving parameters operate at different scales
- A multi-fractal model is seen as an **appropriate approach** to capture and describe the **nested scales of variability of soil moisture patterns**